ANNEX C

Methodology for Estimating Emissions of CH_4, N_2O, and Criteria Pollutants from Stationary Combustion

Estimates of CH_4 and N_2O Emissions

Methane (CH_4) and nitrous oxide (N_2O) emissions from stationary combustion were estimated using IPCC emission factors and methods. Estimates were obtained by multiplying emission factors—by sector and fuel type—by fossil fuel and wood consumption data. This "top-down" methodology is characterized by two basic steps, described below. Data are presented in Table C-1 through Table C-5.

Step 1: Determine Energy Consumption by Sector and Fuel Type

Greenhouse gas emissions from stationary combustion activities were grouped into four sectors: industrial, commercial/institutional, residential, and electric utilities. For CH_4 and N_2O, estimates were based upon consumption of coal, gas, oil, and wood. Energy consumption data were obtained from EIA's *Annual Energy Review* (2000a), and adjusted from higher to lower heating values assuming a 10 percent reduction for natural gas and a 5 percent reduction for coal and petroleum fuels. Table C-1 provides annual energy consumption data for the years 1990 through 1999.

Step 2: Determine the Amount of CH_4 and N_2O Emitted

Activity data for each sector and fuel type were then multiplied by emission factors to obtain emissions estimates. Emission factors were taken from the *Revised 1996 IPCC Guidelines* (IPCC/UNEP/OECD/IEA 1997). Table C-2 provides emission factors used for each sector and fuel type.

Estimates of NO_x, CO, and NMVOC Emissions

For criteria pollutants, the major source categories included were those identified in EPA (2000): coal, fuel oil, natural gas, wood, other fuels (i.e., bagasse, liquefied petroleum gases, coke, coke oven gas, and others), and stationary internal combustion, which includes emissions from internal combustion engines not used in transportation. The EPA (2000) periodically estimates emissions of NO_x, CO, and NMVOCs by sector and fuel type using a "bottom-up" estimating procedure. In other words, the emissions were calculated either for individual sources (e.g., industrial boilers) or for many sources combined, using basic activity data (e.g., fuel consumption or deliveries, etc.) as indicators of emissions. The EPA (2000) projected emissions for years subsequent to their bottom-up estimates. The national activity data used to calculate the individual categories were obtained from various sources. Depending upon the category, these activity data may include fuel consumption or deliveries of fuel, tons of refuse burned, raw material processed, etc. Activity data were used in conjunction with emission factors that relate the quantity of emissions to the activity.

Table C-3 through Table C-5 present criteria pollutant emission estimates for 1990 through 1999.

The basic calculation procedure for most source categories presented in EPA (2000) is represented by the following equation:

$$E_{p,s} = A_s \times EF_{p,s} \times (1 - C_{p,s}/100)$$

where,

E = emissions
p = pollutant
s = source category
A = activity level
EF = emission factor
C = percent control efficiency

The EPA currently derives the overall emission control efficiency of a category from a variety of sources, including published reports, the 1985 National Acid Precipitation and Assessment Program (NAPAP) emissions inventory, and other EPA databases. The U.S. approach for estimating emissions of NO_x, CO, and NMVOCs from stationary combustion as described above is similar to the methodology recommended by the IPCC (IPCC/UNEP/OECD/IEA 1997).

Table C-1: Fuel Consumption by Stationary Combustion for Calculating CH_4 and N_2O Emissions (TBtu)

Fuel/End-Use Sector	1990	1995	1996	1997	1998	1999
Coal	**19,069**	**20,010**	**20,901**	**21,473**	**21,576**	**21,548**
Residential	62	53	54	58	44	44
Commercial/Institutional	93	80	82	87	66	66
Industry	2,725	2,886	2,812	2,827	2,812	3,126
Utilities	16,190	16,990	17,953	18,501	18,654	18,311
Petroleum	**11,743**	**11,359**	**12,026**	**12,274**	**12,291**	**12,584**
Residential	1,266	1,361	1,457	1,432	1,311	1,383
Commercial/Institutional	907	715	741	705	662	701
Industry	8,319	8,624	9,103	9,315	9,152	9,557
Utilities	1,250	658	725	822	1,166	943
Natural Gas	**18,579**	**21,444**	**21,843**	**21,889**	**21,250**	**21,362**
Residential	4,519	4,984	5,390	5,125	4,669	4,830
Commercial/Institutional	2,698	3,117	3,250	3,310	3,098	3,153
Industry	8,500	10,090	10,428	10,432	10,152	10,197
Utilities	2,861	3,253	2,774	3,023	3,330	3,182
Wood	**2,188**	**2,418**	**2,465**	**2,348**	**2,346**	**2,832**
Residential	581	596	595	433	377	404
Commercial/Institutional	37	45	49	47	47	57
Industrial	1,562	1,771	1,813	1,860	1,914	2,364
Utilities	8	7	8	8	7	7

Note: Totals may not sum due to independent rounding.

Table C-2: CH_4 and N_2O Emission Factors by Fuel Type and Sector (g/GJ)[1]

Fuel/End-Use Sector	CH_4	N_2O
Coal		
Residential	300	1.4
Commercial/Institutional	10	1.4
Industry	10	1.4
Utilities	1	1.4
Petroleum		
Residential	10	0.6
Commercial/Institutional	10	0.6
Industry	2	0.6
Utilities	3	0.6
Natural Gas		
Residential	5	0.1
Commercial/Institutional	5	0.1
Industry	5	0.1
Utilities	1	0.1
Wood		
Residential	300	4.0
Commercial/Institutional	300	4.0
Industrial	30	4.0
Utilities	30	4.0

[1] GJ (Gigajoule) = 10^9 joules. One joule = 9.486×10^{-4} Btu

Table C-3: NO_x Emissions from Stationary Combustion (Gg)

Sector/Fuel Type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Electric Utilities	**6,045**	**5,914**	**5,901**	**6,034**	**5,956**	**5,792**	**5,566**	**5,691**	**5,628**	**5,161**
Coal	5,119	5,043	5,062	5,211	5,113	5,061	5,057	5,120	4,932	4,477
Fuel Oil	200	192	154	163	148	87	107	132	202	183
Natural Gas	513	526	526	500	536	510	259	289	346	349
Wood	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Internal Combustion	213	152	159	160	159	134	143	150	149	152
Industrial	**2,754**	**2,703**	**2,786**	**2,859**	**2,855**	**2,852**	**2,864**	**2,814**	**2,768**	**2,844**
Coal	530	517	521	534	546	541	493	487	475	492
Fuel Oil	240	215	222	222	219	224	204	196	190	194
Natural Gas	1,072	1,134	1,180	1,207	1,210	1,202	1,093	1,079	1,066	1,090
Wood	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other Fuels[a]	119	117	115	113	113	111	109	104	104	107
Internal Combustion	792	720	748	783	767	774	965	948	933	961
Commercial/Institutional	**336**	**333**	**348**	**360**	**365**	**365**	**367**	**374**	**353**	**373**
Coal	36	33	35	37	36	35	31	32	34	34
Fuel Oil	88	80	84	84	86	94	87	88	73	73
Natural Gas	181	191	204	211	215	210	224	229	220	241
Wood	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other Fuels[a]	31	29	25	28	28	27	24	25	26	25
Residential	**749**	**829**	**879**	**827**	**817**	**813**	**745**	**710**	**659**	**692**
Coal[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fuel Oil[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Natural Gas[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wood	42	45	48	40	40	44	46	39	34	36
Other Fuels[a]	708	784	831	787	777	769	699	671	624	656
Total	**9,884**	**9,779**	**9,914**	**10,080**	**9,993**	**9,822**	**9,541**	**9,589**	**9,408**	**9,070**

NA (Not Available)

[a] "Other Fuels" include LPG, waste oil, coke oven gas, coke, and non-residential wood (EPA 1999).

[b] Coal, fuel oil, and natural gas emissions are included in the "Other Fuels" category (EPA 1999).

Note: Totals may not sum due to independent rounding.

Table C-4: CO Emissions from Stationary Combustion (Gg)

Sector/Fuel Type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Electric Utilities	**329**	**317**	**318**	**329**	**335**	**338**	**363**	**376**	**379**	**374**
Coal	213	212	214	224	224	227	228	233	220	217
Fuel Oil	18	17	14	15	13	9	11	13	17	16
Natural Gas	46	46	47	45	48	49	72	76	88	85
Wood	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Internal Combustion	52	41	43	46	50	52	53	54	54	55
Industrial	**798**	**835**	**867**	**946**	**944**	**958**	**1,080**	**1,055**	**1,044**	**1,069**
Coal	95	92	92	92	91	88	100	99	96	99
Fuel Oil	67	54	58	60	60	64	49	47	46	47
Natural Gas	205	257	272	292	306	313	308	308	305	310
Wood	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other Fuels[a]	253	242	239	259	260	270	317	302	303	309
Internal Combustion	177	189	205	243	228	222	306	299	294	303
Commercial/Institutional	**205**	**196**	**204**	**207**	**212**	**211**	**130**	**133**	**130**	**136**
Coal	13	13	13	14	13	14	13	13	14	14
Fuel Oil	16	16	16	16	16	17	17	18	15	15
Natural Gas	40	40	46	48	49	49	58	59	57	63
Wood	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other Fuels[a]	136	128	128	129	134	132	42	44	44	45
Residential	**3,668**	**3,965**	**4,195**	**3,586**	**3,515**	**3,876**	**4,048**	**3,403**	**3,022**	**3,220**
Coal[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fuel Oil[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Natural Gas[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wood	3,430	3,711	3,930	3,337	3,272	3,628	3,817	3,174	2,802	2,994
Other Fuels[a]	238	255	265	249	243	248	231	229	220	226
Total	**4,999**	**5,313**	**5,583**	**5,068**	**5,007**	**5,383**	**5,620**	**4,968**	**4,575**	**4,798**

NA (Not Available)

[a] "Other Fuels" include LPG, waste oil, coke oven gas, coke, and non-residential wood (EPA 1999).

[b] Coal, fuel oil, and natural gas emissions are included in the "Other Fuels" category (EPA 1999).

Note: Totals may not sum due to independent rounding.

Table C-5: NMVOC Emissions from Stationary Combustion (Gg)

Sector/Fuel Type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Electric Utilities	**43**	**40**	**40**	**41**	**41**	**40**	**44**	**47**	**50**	**49**
Coal	25	25	25	26	26	26	25	26	26	26
Fuel Oil	5	5	4	4	4	2	3	4	5	5
Natural Gas	2	2	2	2	2	2	7	7	9	8
Wood	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Internal Combustion	11	9	9	9	9	9	9	10	10	10
Industrial	**165**	**177**	**169**	**169**	**178**	**187**	**162**	**160**	**159**	**162**
Coal	7	5	7	5	7	5	6	6	6	6
Fuel Oil	11	10	11	11	11	11	8	7	7	7
Natural Gas	52	54	47	46	57	66	54	54	54	54
Wood	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other Fuels[a]	46	47	45	46	45	45	32	31	31	32
Internal Combustion	49	61	60	60	58	59	63	62	61	63
Commercial/Institutional	**18**	**18**	**20**	**22**	**21**	**21**	**24**	**24**	**24**	**26**
Coal	1	1	1	1	1	1	1	1	1	1
Fuel Oil	3	2	3	3	3	3	3	3	3	3
Natural Gas	7	8	9	10	10	10	13	13	12	14
Wood	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other Fuels[a]	8	7	7	8	8	8	8	8	8	9
Residential	**686**	**739**	**782**	**670**	**657**	**726**	**739**	**617**	**546**	**582**
Coal[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fuel Oil[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Natural Gas[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wood	651	704	746	633	621	689	707	585	516	552
Other Fuels[a]	35	35	36	36	36	37	33	32	30	31
Total	**912**	**975**	**1,011**	**901**	**898**	**973**	**971**	**848**	**778**	**820**

NA (Not Available)

[a] "Other Fuels" include LPG, waste oil, coke oven gas, coke, and non-residential wood (EPA 1999).

[b] Coal, fuel oil, and natural gas emissions are included in the "Other Fuels" category (EPA 1999).

Note: Totals may not sum due to independent rounding.